WAVEGUIDE DIPLEXING AND FILTERING DEVICE

FIELD OF THE INVENTION

The present invention relates to a waveguide diplexing and filtering device, and in particular, a waveguide device that provides diplexing and filtering of an electromagnetic or microwave signal such that two polarities of one frequency band and at least one polarity of another frequency band are separated.

BACKGROUND OF THE INVENTION

It is well known that various communication systems employ more than one frequency band when transmitting electromagnetic or microwave signals from a transmitting station to a receiving station. A typical example of such a communication system is a satellite communication system wherein various bands of signals are transmitted between a satellite above the earth (geosynchronous orbit) and ground stations on the earth. Two such frequency bands of interest herein include the Ka band of 20 GHZ, which ranges from 19.7 to 20.2 GHZ, and the Ku band of 12 GHZ, which ranges between 11.7 to 12.7 GHZ.

Historically, the practice has been to provide separate antennas for transmission or reception of each of the bands because there is insufficient band width on any one of the antenna systems or terminals to transmit more than one of the bands. In some cases, where bands are close together and, collectively, do not occupy an excess amount of spectral space, it has been possible to share a plurality of bands on one antenna. However, separate antennas have been employed for different portions of the spectrum.

Microwave multi-plexers have been developed and utilized in communication systems, such as satellite communication systems, for combining numerous signal channels for transmission along a common transmission path, such as an antenna feed. In a frequently employed form of satellite communication system, an antenna carried by a satellite transmits and/or receives electromagnetic signals propagating between a satellite and an antenna located on the earth's surface. Plural signal channels separated by frequency and/or by polarization are communicated by the two antennas. It is important that the signals of all the channels, whether they are literally polarized or circularly polarized, propagate along the same path in a common direction so that all of the signals transmitted by a transmitting antenna reach a receiving antenna.

While such multi-plexers have been employed in both land-based and in satellite communication systems, problems arise in that multi-plexers are typically complex and heavy in their mechanical structure. Such multi-plexers are typically designed for low-volume, high-performance systems, but the manufacturing costs are prohibitive for high volume, low cost components. Therefore, it would be desirable to provide a simple, lightweight, and inexpensive diplexer that could accommodate various frequencies and polarities.

SUMMARY OF THE INVENTION

The present invention provides a waveguide diplexing and filtering device for separating two polarities of one frequency band and at least one polarity of another frequency band of an electromagnetic or microwave signal. The present invention provides an enclosure having a longitudinal axis wherein a common channel is formed in the enclosure and terminates at a common port. The common channel and common port are adapted to receive

a microwave signal having at least two substantially different frequencies including an upper frequency and a lower frequency, wherein the lower frequency signal includes two polarities. A side channel is formed in the enclosure and terminates at a side port. The side channel is in communication with the common channel and is adapted to cut off the lower frequency of the microwave signal and allow the upper frequency of the microwave signal to propagate through the side channel to the side port. A main channel is formed in the enclosure and terminates at a main port. The main channel is in communication with the common channel. At least one waveguide iris element is mounted within the main channel and is adapted to filter the upper frequency of the microwave signal and allow two polarities of the lower frequency of the microwave signal to pass through the iris element and propagate along the main channel to the main port. A feed horn may be coupled to the common port and adapted to direct the microwave signal into the common port. The side port and the main port are communicable with a low noise block (LNB) converter to amplify and reduce the frequencies to a lower frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout several views and wherein:

FIGURE 1 is a perspective view of the waveguide diplexing and filtering device of the present invention.

FIGURE 2 is a perspective view showing the waveguide diplexing and filtering device of the present invention mounted to an antenna dish.

FIGURE 3 is a perspective cross-sectional view of the waveguide diplexing and

filtering device of the present invention.

FIGURE 4 is a perspective view of a waveguide iris element of the waveguide diplexing and filtering device of the present invention.

FIGURE 5 is a perspective view of a feed horn of the waveguide diplexing and filtering device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings the present invention will now be described in detail with reference to the disclosed embodiment.

FIGURES 1-3 illustrate a waveguide diplexing and filtering device **10** of the present invention for separating two polarities of one frequency band and at least one polarity of another frequency band of an electromagnetic or microwave signal. The waveguide device **10** provides an enclosure **12** having a common port **14**, a main port **16**, and a side port **18**. A feed horn **20** may be coupled to the common port **14** of the enclosure **12** to direct and guide the electromagnetic or microwave signal into the common port **14.** Low noise block (LNB) converters **22**, **24** are connected to the main port **16** and the side port **18**, respectively, of the enclosure **12.** The LNB's **16**, **18** amplify and convert the separated frequency bands into a lower frequency that may be utilized by a receiver. The waveguide device **10** may be mounted to an antenna dish **26** for receiving and/or transmitting the electromagnetic or microwave signal. Although the drawings depict only one waveguide device **10** being utilized, the present invention also anticipates the use of more than one waveguide device **10** to provide further multiplexing or diplexing of the electromagnetic or microwave signal.

The present invention is ideally suited for receiving an electromagnetic or microwave

signal having a Ku band signal with two polarities and a Ka band signal with a single polarity. The Ku band has a substantially 12 GHz signal ranging from 10.7 to 12.75 GHz. The Ka band is a higher frequency having a substantially 20 GHz signal ranging from 19.7 to 20.2 GHz. The polarities of the Ka band frequency are linear thereby providing a horizontal and a vertical polarity signal. Although the embodiment described in the specification is designed to accommodate an electromagnetic or microwave signal having a Ku band signal with two polarities and a Ka band with a single polarity, certain dimensional changes may be made to the waveguide device **10** to allow for the accommodation of an electromagnetic or microwave signal having different frequency bands and polarities. The polarities may also be converted prior to being separated and filtered by the waveguide device. For instance, a polarizer (not shown) may be utilized to convert a circular polarity signal into a linear polarity signal prior to the microwave signal being separated and filtered by the waveguide device **10**.

In order to gather and direct the proper microwave signal into the waveguide device **10**, the feed horn **20** provides a substantially cylindrical structure having concentric rings **21** which decrease in diameter as they approach the common port **14**, as seen in Figure 5. The feed horn **20** is fabricated from a conductive material, such as cast zinc or aluminum, which allows the microwave signal to propagate through the feed horn **20.** The feed horn **20** is designed to receive the microwave signal at the focal point of the antenna dish **26** and is designed to accept satellite signals while rejecting unwanted signals, such as those bounced from nearby walls or from nearby telephone and/or television towers that might not have an antenna dish. The concentric or scalar rings **21** of the feed horn **20** are designed to accept desired signals and assist in rejecting undesired frequencies. The feed horn **20** is connected to and communicates with the common port **14** to direct the microwave signal into the enclosure

12 of the waveguide device **10.**

To separate and filter the microwave signal, the enclosure **12** of the waveguide device **10** is fabricated from a conductive material, such as cast zinc or aluminum, having a substantially rectangular portion **28** and a substantially cylindrical portion **30**, as seen in Figures 1-3. The rectangular portion **28** has a common channel **32** that terminates at the common port **14**. The common port **14** opens to an end wall **34** provided on the rectangular portion **28** of the enclosure **12**. The common channel **32** extends along a longitudinal axis **36** that is common to and coaxial with a longitudinal axis **36** of the enclosure **12**. The common channel **32** and the common port **14** have a substantially square cross-section having sides that are 0.574 inches in length. The size of the common channel **32** determines which frequencies of the signal are cut off by the waveguide device **10**.

To filter the microwave signal, the common channel **32** communicates and is continuous with a main channel **38** which terminates at the main port **16**. The main port **16** opens into an end wall **39** of the cylindrical portion **30** of the enclosure **12**. The main channel **38** has a longitudinal axis **36** that is coaxial with the longitudinal axis **36** of the enclosure **12** and the common channel **32.** The main channel **38** also has a substantially square cross-section having the same dimensions as the common channel **32**. Again, the size of the main channel **38** determines which frequencies are cut off by the waveguide device **10**. The main channel **38** is disposed within the cylindrical portion **30** of the enclosure **12.** Two slots **39** are provided within the main channel **38** for capturing two waveguide iris elements **40, 42**. The waveguide iris elements **40, 42** are fabricated from a thin, substantially circular conductive material that spans across the main channel **38**. As seen in Figures 3 and 4, each waveguide

iris element **40**, **42** is 0.025 inches thick and provides a substantially rectangular locating tab **44** which complementarily engages the slot **39** in the main channel **38** to radially locate the waveguide iris elements **40**, **42** in their proper position. The spacing between the waveguide iris elements **40**, **42** is a function of the wave length of the frequency band of the microwave signal. However, the relationship is complex and was partially determined by experiment. Thus, spacing of the waveguide iris elements **40**, **42** in the present invention is 0.985 inches.

In order to filter the lower frequency Ku band signal from the higher frequency Ka band signal, each waveguide iris element **40**, **42** has a substantially vertical slot **46** and a substantially horizontal slot **48** extending therethrough. The vertical slot **46** and the horizontal slot **48** have longitudinal axes **50**, **52**, respectively, that are substantially perpendicular to one another. Each slot **46**, **48** has a substantially rectangular mid portion **54** and a pair of substantially arcuate end portions **56** that are integral with the rectangular mid portion **54.** The size of the slots **46**, **48** are designed to allow the lower frequency Ku band signal to pass and propagate through the slots **46**, **48** while the upper frequency Ka band signal is prevented from passing through the waveguide iris elements **40**, **42**. To accomplish this, each rectangular mid portion **54** of the slots **46**, **48** has a width of 0.150 inches. The length of the rectangular mid portions **54** are determined by the center line distances of the arcuate end portions **56**. The distance between the center line axes of the arcuate end portions **56** is 0.382 inches. The radius of each arcuate end portions **56** is 0.096 inches. The vertical slot **46** allows for the passage of the vertical polarity of the Ku band signal, and the horizontal slot **48** allows for the passage of the horizontal polarity of the Ku band signal. The use of the two waveguide iris elements **40**, **42** enhances the filtering of the Ku band signal. It should be

noted that the present invention anticipates using additional waveguide iris elements to further enhance the filtering. Additional main channels could also be implemented with waveguide iris elements to provide filtering of additional frequency bands of the microwave signal.

To separate the higher frequency Ka band signal from the lower frequency Ku band signal, the side port **18**, which terminates in an end wall **57** of the rectangular portion **28** of the enclosure **12**, is in communication with a side channel **58.** The side channel **58** is housed in a side arm portion **60** of the rectangular portion **28** of the enclosure **12.** The side channel **58** has a longitudinal axis **62** that is substantially perpendicular to the longitudinal axis **36** of the enclosure **12**, the common channel **32**, and the main channel **38**. However, the present invention anticipates that the side channel **58** could extend at various angles to the longitudinal axis **36** of the enclosure **12**. The side channel **58** has a substantially rectangular cross-section and utilizes a waveguide cutoff theory to propagate only the higher frequency Ka band along the side channel **58.** The waveguide cutoff is based on the formula:

$$f_c = c/2a$$

where f_c is the frequency below which all signals are cut off, c is the speed of light, and a equals the dimension of the waveguide perpendicular to the polarity of the signal. The width of the side channel **58** is 0.420 inches and the height of the side channel **58** is 0.060 inches. As noted in the above formula, the size of the width of the side channel **58** determines the frequency cut off. However, the height of the side channel **58** is immaterial since the higher frequency Ka band has a single polarity substantially perpendicular to the width of the side channel **58**. The side channel **58** extends in the H (magnetic) plane, but the

side channel **58** could be oriented in the E (electrical) plane. Although the side channel **58** is substantially rectangular, the side channel **58** could be substantially square, round or otherwise to support two polarities instead of one.

In operation, the waveguide device **10** is mounted to the antenna dish or satellite antenna **26**. The waveguide device **10** is spaced so that the focal point of the microwave signal received by the antenna dish **26** is located at the feed horn **20** of the waveguide device **10**. The electromagnetic or microwave signal propagates into the common port **14** and along the common channel **32**. The electromagnetic or microwave signal is filtered by the waveguide iris elements **40, 42** which allow the lower frequency Ku band to pass through the waveguide iris elements **40, 42** and propagate along the main channel **38** where the LNB **22** amplifies and converts the Ku band signal to a lower frequency. The higher frequency Ku band propagates along the side channel **58** where it is received by the LNB **24**. The LNB **24** amplifies and converts the Ka band signal to a lower frequency.

While the description has been described in connection with what is presently considered to be the most practical and preferred embodiment, it should be understood that the invention is not to be limited to those disclosed in the embodiment, but to the contrary, it is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims which scope is intended to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.